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about 18°. For any neighbouring position the beginning and ending of the total phase may be determined from the expressions

$$\cos \omega = -110{\cdot}2757 - [2{\cdot}08444] \sin l + [1{\cdot}62804] \cos l \,.\, \cos (\lambda - 160^\circ\ 52'{\cdot}8)$$
$$t = 8^{h}\ 58^{m}\ 13^{s}{\cdot}6 \mp [1{\cdot}77303] \sin .\, \omega - [3{\cdot}38763] \sin l$$
$$- [3{\cdot}85920] \cos l \,.\, \cos (\lambda - 145^\circ\ 34'{\cdot}2)$$

At Wellington totality begins at 19^{h} 44^{m} 9^{s} local mean time, and continues 1^{m} 31^{s}. At Nelson it begins at 19^{h} 37^{m} 22^{s}, and continues 1^{m} 11^{s}.

The Greenwich time of commencement of the eclipse, near Castle Point, may be found from the expressions

$$\cos \omega = -1{\cdot}55171 - [0{\cdot}24636] \sin l + [9{\cdot}74289] .\, \cos l \,.\, \cos (\lambda - 178^\circ\ 48'{\cdot}8)$$
$$t = 9^{h}\ 2^{m}\ 51^{s}{\cdot}9 - [3{\cdot}57430] \sin \omega - [3{\cdot}29927] \sin l$$
$$- [3{\cdot}82250] \cos .\, l \,.\, \cos (\lambda - 161^\circ\ 21'{\cdot}5)$$

The contact takes place at about 62° N. to W. (direct). For Castle Point the equations give the partial beginning at 18^{h} 45^{m} 47^{s} local mean time. The Sun will be at an altitude of 6½°.

With regard to the latitude limits of total phase, they may be stated approximately at $+49'$ for N. limit and $-50'$ for S. limit, but a closer computation appears unnecessary. For satisfactory observation during the totality of the approaching eclipse, the observer must place himself as nearly as practicable upon the central line. It will be found that the above determination of its course, from my own computations, agrees closely with that indicated in the *American Ephemeris.*

The Observations of the Moon made at the Radcliffe Observatory, during the year 1884, *and a Comparison of the Results with the Tabular Places from Hansen's Lunar Tables.* By E. J. Stone, M.A., F.R.S.

The present paper contains the Right Ascensions and North Polar Distances of the Moon as deduced from the observations made at the Radcliffe Observatory during the year 1884. I have compared these results with those deduced from Hansen's Lunar Tables on two suppositions:—

1. That the mean times, found in the usual way from the sidereal times at mean noon given in the *Nautical Almanac*, were not changed in 1864.
2. That the mean times were changed in 1864, in accordance

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with the views which I have explained in papers already communicated to the Society.

The following facts should be borne in mind:—

(1) Hansen's Lunar Tables represented the motions of the Moon with great accuracy for many years before 1863. The mean yearly error, 1847–1864, was always small, generally about $-1''\cdot5$.

(2) In 1864 we changed the scale upon which our mean times are measured, or the ratio of the sidereal day to the tabular day. This is now admitted.

(3) I have given mathematical proofs, which no one in my opinion has shown to be in error, that this change of unit requires the correction

$$24^{\mathrm{h}}.\frac{\delta n}{n}.t$$

to be applied to our present sidereal times at mean noon, in order to obtain the sidereal time at Bessel's old mean noon, to which our tabular quantities refer. This correction is equivalent to a change of the adopted unit in the proportion of

$$1:\left(1+\frac{\delta n}{n}\right).$$

(4) When this correction is applied to our mean times, the discordances between Hansen's Lunar Tables and observations for the twenty-one years 1864–1884 are sensibly the same as they were before 1863.

The mean of the four greatest negative errors in the comparison of Hansen's Tables in Longitude with the Greenwich observations was $-9''\cdot08$ in 1862, and $-6''\cdot95$ in 1863; whilst the mean of the four greatest positive errors was respectively $+1''.51$ in 1862, and $+3''\cdot52$ in 1863. The Radcliffe observations in 1882, 1883, and 1884, show corresponding mean errors of $-7''\cdot17$, $-6''\cdot60$, and $-8''\cdot01$, and $+3''\cdot93$, $+3''\cdot50$, and $+4''\cdot69$ respectively.

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TABLE I.

Radcliffe Observations of the Moon, 1884.

Corr. to be subtracted from M.T. computed directly from Sid. Time at Mean Noon from N.A.	Obs.	Day. 1884.		Observed R.A.	Secs. of Hansen's R.A.	Diff. (H.−Obs.)	Corr. due to Error in Time.	Residual Error in R.A.	Observed N.P.D.	Secs. of Hansen's N.P.D.	Diff. (H.−Obs.)	Corr. due to Error in Time.	Residual Error in N.P.D.
s				h m s	s	s	s	s	° ′ ″	″	″	″	″
29·83	R.	Jan.	10	5 48 51·52	52 28	+0·76	−1·27	−0·51	70 51 51·14	50·29	−0·85	−0·47	−1·32
29·83	R.		11	6 52 7·49	8·26	+0·77	−1·24	−0·47	71 55 30·37	31·84	+1·47	−2·03	−0·56
29·84	F.B.		12	7 53 10·64	11·78	+1·14	−1·19	−0·05					
29·92	F.B.	Feb.	2	1 24 55·80	56·62	+0 82	−1·13	−0·31	80 47 61·08	59·57	−1·51	+5·05	+3·54
29·94	R.		6	5 24 36·72	37·29	+0·57	−1·24	−0·67	70 59 35·88	34·55	−1·33	+0·22	−1·11
29·94	F.B.		7	6 26 22·56	23·47	+0·91	−1·23	−0·32	71 27 27·93	31·64	+3·71	−1·31	+2·40
30·05	R.	Mar.	5	6 7 14·46	15·14	+0·68	−1·22	−0·54	71 22 4·39	6·74	+2·35	−0·80	+1·55
30·05	F.B.		6	7 7 1·98	2 81	+0·83	−1·18	−0·35	72 36 59·51	61·37	+1·86	−2·17	−0·31
30·06	R.		7	8 4 48 20	48·89	+0·69	−1·14	−0·45	74 54 29 72	32·55	+2·83	−3·32	−0·49
30·06	F.B.		8	9 0 13·69	14·51	+0·82	−1·09	−0·27	78 1 50·18	53·99	+3·81	−4·18	−0·37
30·07	R.		10	10 44 35·18	35·90	+0·72	−1·02	−0·30	85 48 27·37	32·25	+4 88	−5·06	−0·18
30·08	R.		12	12 23 12·38	13·26	+0·88	−0·98	−0·10	94 6 36·56	39·22	+2 66	−4·88	−2·22
30·09	R.		14	14 0 19·89	20·85	+0·96	−0 99	−0·03	101 25 2·98	4·80	+1·82	−3·89	−2·07
30·10	R.		18	17 21 53·54	54·66	+1·12	−1·06	+0·06	108 42 34·30	34·40	+0·10	−0·26	−0·16

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Corr. to be subtracted from M.T. computed directly from Sid.Time at Mean Noon from N.A.	Obs.	Day. 1884.		Observed R.A.	Secs. of Hansen's R.A.	Diff. (H.–Obs.)	Corr. due to Error in Time.	Residual Error in R.A.	Observed N.P.D.	Secs. of Hansen's N.P.D.	Diff. (H.–Obs.)	Corr. due to Error in Time.	Residual Error in N.P.D.
s				h m s	s	s	s	s	° ′ ″	″	″	″	″
30·17	F.B.	Apr.	5	9 36 39·43	40·40	+0·97	–1·06	–0·09	80 34 55·02	58·46	+3·44	–4·54	–1·10
30·19	F.B.		9	12 53 55·01	55·92	+0·91	–0·98	–0·07	96 35 19·78	23·74	+3·96	–4·62	–0·66
30·19	W.		10						100 10 36·37	43·28	+6·91	–4·12	+2·79
30·20	F.B.		12	15 20 47·09	48·43	+1·34	–1·02	+0·32	105 47 7·69	9·81	+2·12	–2·63	–0·51
30·29	F.B.	May	3	10 12 17·67	18·54	+0·87	–1·03	–0·16	83 14 6·57	11·23	+4·66	–4·85	–0·19
30·29	R.		5	11 50 34·99	35·83	+0·84	–0·98	–0·14	91 22 39·19	43·30	+4·11	–4·97	–0·86
30·30	F.B.		6	12 38 25·59	26·54	+0·95	–0·97	–0·02	95 20 45·73	48·69	+2·96	–4·72	–1·76
30·30	R.		7	13 26 17·65	18·35	+0·70	–0·98	–0·28	99 2 22·55	25·21	+2·66	–4·30	–1·64
30·31	F.B.		8	14 14 40·11	41·21	+1·10	–0·99	+0·11	102 18 54·70	57·44	+2·74	–3·70	–0·96
30·31	R.		9	15 3 53·84	54·70	+0·86	–1·01	–0·15	105 2 13·61	15·92	+2·31	–2·94	–0·63
30·31	F.B.		10	15 54 5·04	6·25	+1·21	–1·03	+0·18	107 4 53·91	53·94	+0·03	–2·05	–2·02
30·44	W.	June	10	19 4 34·59	36·06	+1·47	–1·07	+0·40	107 32 45·94	44·63	–1·31	+1·85	+0·54
30·44	F.B.		11	19 56 35·90	37·26	+1·36	–1·06	+0·30	105 37 12·17	10·70	–1·47	+2·87	+1·40
30·53	F.B.	July	2	14 31 19·34	20·42	+1·08	–1·00	+0·08	103 4 17·41	21·34	+3·93	–3·55	+0·38
30·53	W.		3	15 20 39·68	40·72	+1·04	–1·02	+0·02	105 38 5·14	7·77	+2·63	–2·75	–0·12
30·55	R.		7	18 47 15·94	17·01	+1·07	–1·08	–0·01	108 1 61·42	59·33	–2·09	+1·45	–0·64
30·55	W.		8	19 39 53·07	54·24	+1·17	–1·08	+0·09	106 24 61·10	59·30	–1·80	+2·52	+0·72
30·55	F.B.		9	20 32 9·69	10·95	+1·26	–1·07	+0·19	103 57 55·39	51·30	–4·09	+3·49	–0·60

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Corr. to be subtracted from M.T. computed directly from Sid.Time at Mean Noon from N.A.	Obs.	Day. 1884.		Observed R.A.	Secs. of Hansen's R.A.	Diff. (H.−Obs.)	Corr. due to Error in Time.	Residual Error in R.A.	Observed N.P.D.	Secs. of Hansen's N.P.D.	Diff. (H.−Obs.)	Corr. due to Error in Time.	Residual Error in N.P.D.
s				h m s	s	s	s	s	° ′ ″	″	″	″	″
30·56	R.	July	11	22 15 26·40	27·57	+1·17	−1·06	+0·11	97 1 15·91	11·86	−4·05	+4·93	+0·88
30·64	W.		31	15 52 16·01	17·01	+1·00	−1·04	−0·04	106 41 6·67	5·36	−1·31	−2·23	−3·54
30·65	R.	Aug.	1	16 43 12·19	13·12	+0·93	−1·06	−0·13	108 5 8·29	7·22	−1·07	−1·23	−2·30
30·65	F.B.		2	17 35 1·63	2·67	+1·04	−1·08	−0·04	108 38 46·00	45·29	−0·71	−0·15	−0·86
30·66	F.B.		4	19 20 23·29	24·31	+1·02	−1·09	−0·07	107 4 15·64	11·88	−3·76	+2·09	−1·67
30·66	W.		5	20 13 15·44	16·50	+1·06	−1·09	−0·03	104 56 54·56	49·80	−4·76	+3·14	−1·62
30·67	F.B.		6	21 5 54·25	55·66	+1·41	−1·08	+0·33	102 1 38·81	34·36	−4·45	+4·05	−0·40
30·67	W.		7	21 58 17·91	19·29	+1·38	−1·08	+0·30	98 26 17·66	13·78	−3·88	+4·78	+0·90
30·76	R.		29	17 14 3·32	4·01	+0·69	−1·07	−0·38	108 20 17·01	16·17	−0·84	−0·61	−1·45
30·77	R.	Sept.	1	19 51 5·45	6·32	+0·87	−1·09	−0·22	105 50 15·58	12·11	−3·47	+2·67	−0·80
30·77	F.B.		2	20 43 53·34	54·36	+1·02	−1·09	−0·07	103 16 26·75	22·16	−4·59	+3·67	−0·92
30·78	W.		4	22 29 47·47	48·43	+0·96	−1·10	−0·14	96 2 35·15	30·54	−4·61	+5·15	+0·54
30·79	R.		5	23 23 15·74	16·74	+1·00	−1·11	−0·11	91 42 38·70	33·78	−4·92	+5·54	+0·62
30·87	W.		27	18 36 9·97	10·95	+0·98	−1·08	−0·10	107 55 15·80	14·33	−1·47	+1·10	−0·37
30·88	R.		29	20 20 6·31	7·11	+0·80	−1·08	−0·28	104 26 58·33	55·21	−3·12	+3·19	+0·07
30·89	W.		30	21 12 19·28	20·25	+0·97	−1·09	−0·12	101 30 53·29	48·02	−5·27	+4·10	−1·17
30·90	R.	Oct.	3	23 52 35·95	36·86	+0·91	−1·14	−0·23	89 15 46·66	43·28	−3·38	+5·68	+2·30
30·90	F.B.		4	0 48 34·51	35·59	+1·08	−1·18	−0·10	84 42 13·26	10·50	−2·76	+5·58	+2·82

Corr. to be subtracted from M.T. computed directly from Sid. Time at Mean Noon from N.A.	Obs.	Day. 1884.	Observed R.A.	Secs. of Hansen's R.A.	Diff. (H.–Obs.)	Corr. due to Error in Time.	Residual Error in R.A.	Observed N.P.D.	Secs. of Hansen's N.P.D.	Diff. (H.–Obs.)	Corr. due to Error in Time.	Residual Error in N.P.D.
s			h m s	s	s	s	s	° ′ ″	″	″	″	″
30·93	R.	Oct. 12	8 53 36·72	37·73	+1·01	–1·16	–0·15	77 21 14·97	18·24	+3·27	–4·06	–0·79
31·00	W.	28	21 40 27·03	27·97	+0·94	–1·07	–0·13	99 41 19·39	15·07	–4·32	+4·45	+0·13
31·00	R.	29	22 32 11·70	12·65	+0·95	–1·09	–0·14	95 51 12·78	9·17	–3·61	+5·10	+1·49
31·02	R.	Nov. 3	3 18 49·66	50·75	+1·09	–1·32	–0·23	74 58 43·71	40·57	–3·14	+3·64	+0·50
31·03	R.	6	6 33 52·30	53·41	+1·11	–1·32	–0·21	71 58 10·62	11·40	+0·78	–1·28	–0·50
31·04	F.B.	7	7 36 24·70	26·18	+1·48	–1·27	+0·21	73 36 12·09	13·56	+1·47	–2·73	–1·26
31·05	R.	9	9 32 7·61	8·67	+1·06	–1·14	–0·08	79 41 10·64	17·48	+6·84	–4·61	+2·23
31·11	R.	24	21 20 22·87	23·55	+0·68	–1·05	–0·37	101 12 43·33	39·68	–3·65	+4·06	+0·41
31·12	R.	28	0 47 13·18	14·02	+0·84	–1·15	–0·31	84 56 58·68	54·24	–4·44	+5·55	+1·11
31·13	F.B.	29	1 44 7·08	8·12	+1·04	–1·22	–0·18	80 37 60·26	57·13	–3·13	+5·18	+2·05
31·23	W.	Dec. 26	1 18 24·29	25·37	+1·08	–1·15	–0·07	82 45 44·47	41·96	–2·51	+5·25	+2·74
31·25	W.	30	5 24 15·12	15·97	+0·85	–1·39	–0·54	71 34 28·72	27·91	–0·81	+0·69	–0·12
31·25	F.B.	31	6 31 26·47	27·48	+1·01	–1·39	–0·38	71 45 3·37	4·81	+1·44	–1·15	+0·29
Mean of Errors without regard to sign ...					0·989		0·207			2·907		1·140
Mean Errors for Year					+0·989		–0·120			–0·270		–0·094

Observers.—W., Mr. Wickham; R., Mr. Robinson; F.B., Mr. Bellamy.

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TABLE II.

Radcliffe Observations of the Moon, 1884.

Errors of Longitude and Ecliptic Polar Distance. Corrected and Uncorrected for Error in Mean Time.

Day, 1884.	Errors of Longitude. *Corrected* for Error in Time.	*Uncorrected.*	Errors of E.N.P.D. *Corrected* for Error in Time.	*Uncorrected.*
	″	″	″	″
Jan. 10	−7·22	+10·82	−1·47	−0·62
11	−6·75	+11·11	+0·04	+0·48
Feb. 2	−5·58	+11·84	+1·58	+3·12
6	−9·44	+ 8·17	−1·70	−0·82
7	−4·46	+13·14	+2·60	+3·12
Mar. 5	−7·69	+ 9·74	+1·66	+2·21
6	−5·03	+12·06	+0·28	+0·46
7	−6·50	+10·41	−0·86	+0·72
8	−3·92	+12·67	+0·77	+0·25
10	−4·23	+11·85	+1·52	+0·05
12	−2·25	+13·14	−1·44	−2·78
14	−1·13	+13·83	−1·79	−3·16
18	+0·84	+15·96	−0·22	−0·95
Apr. 5	−1·62	+14·75	−0·61	−1·38
9	−1·22	+14·05	−0·21	−1·59
12	+4·34	+19·27	−1·68	−2·91
May 3	−2·30	+13·81	+0·67	−0·26
5	−2·27	+13·22	+0·05	−1·24
6	−0·97	+14·20	−1·50	−2·85
7	−4·46	+10·62	+0·02	−1·38
8	+1·20	+16·13	−1·44	−2·77
9	−2·26	+12·62	0·00	−1·23
10	+2·11	+17·01	−2·52	−3·59
June 10	+5·65	+21·12	+1·17	+1·02
11	+4·00	+19·65	+2·21	+2·37
July 2	+1·23	+16·22	−0·01	−1·23
3	+0·25	+15·23	−0·19	−1·31
7	−0·09	+15·45	−0·65	−0·81
8	+1·16	+16·94	+0·93	+1·06
9	+2·84	+18·85	+0·10	+0·54
11	+1·22	+17·76	+1·41	+2·48

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Day, 1884.	Errors of Longitude.		Errors of E.N.P.D.	
	Corrected for Error in Time.	*Uncorrected.*	*Corrected* for Error in Time.	*Uncorrected.*
	″	″	″	″
July 31	−1·31	+13·79	−3·34	−4·32
Aug. 1	−2·15	+13·06	−2·04	−2·80
2	−0·61	+14·81	−0·83	−1·33
4	−0·77	+15·06	−1·79	−1·73
5	−0·07	+16·09	−1·68	−1·25
6	+4·76	+21·15	+1·02	+1·73
7	+3·88	+20·61	+2·37	+3·40
29	−5·52	+ 9·75	−1·02	−1·62
Sept. 1	−2·98	+13·03	−1·38	−1·06
2	−0·75	+15·63	−1·16	−0·53
4	−2·14	+15·04	−0·27	+1·00
5	−1·76	+15·75	−0·08	+1·37
27	−1·41	+14·11	−0·46	−0·60
29	−3·99	+12·07	−0·86	−0·38
30	−1·34	+15·23	−1·64	−0·80
Oct. 3	−4·08	+13·88	+0·74	+2·33
4	−2·48	+15·94	+2·01	+3·74
12	−2·34	+15·17	−0·16	−0·91
28	−1·86	+14·59	−0·50	+0·45
29	−2·50	+14·53	+0·61	+1·89
Nov. 3	−3·35	+16·09	−0·38	+1·06
6	−3·03	+15·92	−0·32	−0·15
7	+2·78	+21·32	−1·73	−2·01
9	−0·41	+17·06	+2·49	+1·50
24	−5·32	+10·66	−1·27	−0·42
28	−4·70	+13·29	−0·78	+0·80
29	−3·22	+15·50	+0·96	+2·59
Dec. 26	−2·00	+15·85	+2·15	+3·70
30	−7·68	+12·16	−0·60	−0·05
31	−5·41	+14·49	+0·59	+0·64
Mean of errors without regard to sign	3·096	14·645	1·091	1·556
Mean errors for year	−1·907	+14·645	−0·146	−0·111

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TABLE III.

Observations of the Moon, 1862 to 1884.

Mean Errors of Longitude. Uncorrected and Corrected for Error in Mean Time.

Year.		Errors of Longitude. (Hansen − Observed).	
		Uncorrected.	*Corrected.*
1862	Greenwich	− 2″·829	−2″·829
1863		− 1·606	−1·606 *
1864		+ 0·121	−0·814
1865		+ 1·271	−0·220
1866		+ 2·142	−0·217
1867		+ 3·480	+0·357
1868		+ 4·117	+0·280
1869		+ 4·277	−0·352
1870		+ 4·828	−0·657
1871		+ 6·955	+0·435
1872		+ 7·309	+0·097
1873		+ 8·239	+0·200
1874		+ 9·294	+0·561
1875		+ 9·867	+0·365
1876		+ 9·800	−0·509
1877		+ 9·234	−1·898
1878		+ 8·219	−3·603
1879		+ 9·631	−3·124
1880		+10·265	−3·245
1881		+10·622	−3·791
1882	Radcliffe	+12·927	−2·508
1883	,,	+14·615	−1·547
1884	,,	+14·645	−1·907

On Screw-wear as affecting the N.P.D. of the Cape Catalogue for 1880. By E. J. Stone, M.A., F.R.S.

The statement which Mr. Gill has made of the existence of serious systematic errors in the North Polar Distances of the Cape Catalogue for 1880, due to the wear of the screws of the Transit Circle between 1856 and 1879, is one which is easily made; but which it will be found much more difficult to prove than to make.

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* Here change in the unit of time took place.